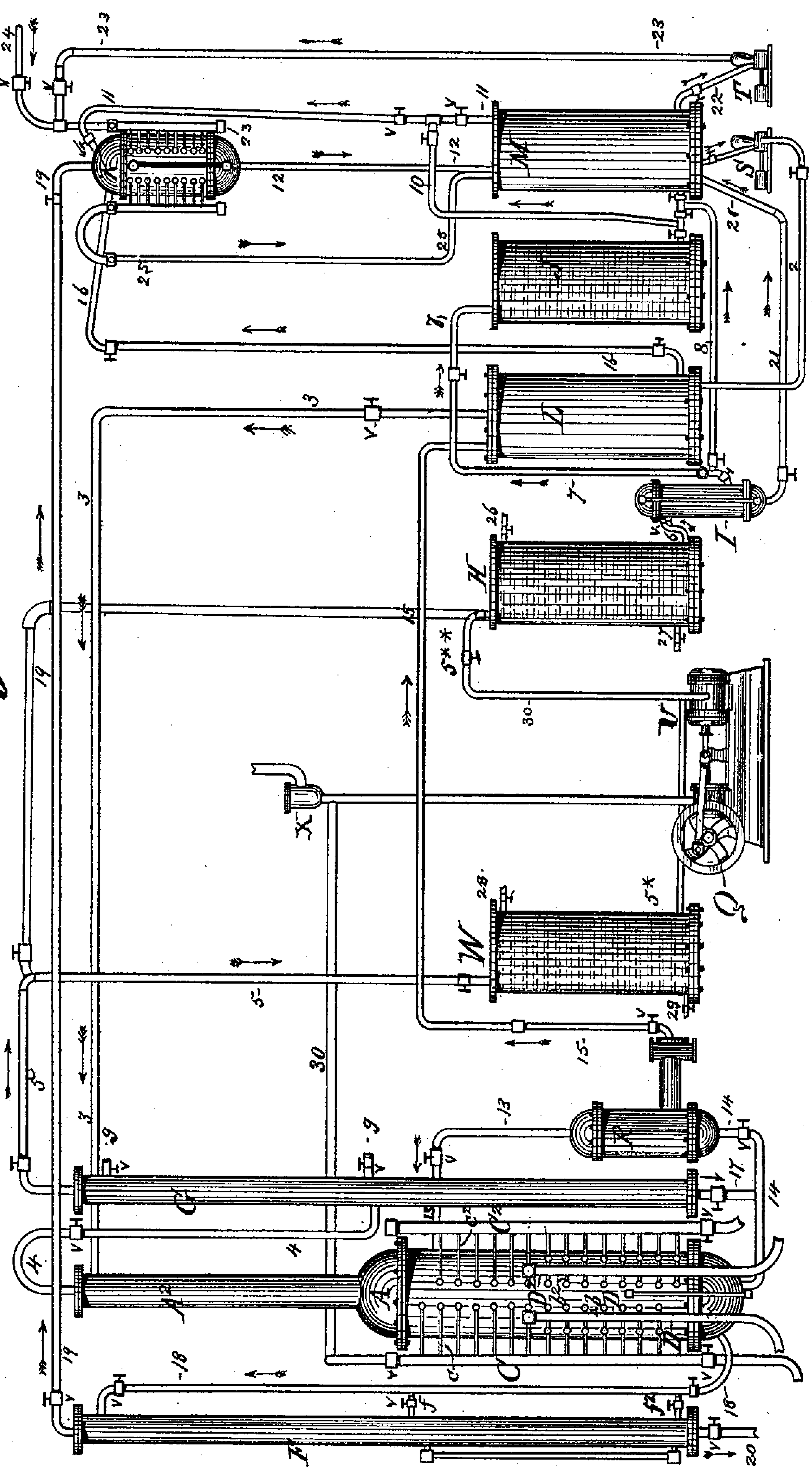
(No Model.) 4 Sheets—Sheet 1.

E. E. HENDRICK.

MACHINE FOR COOLING LIQUIDS AND OTHER ARTICLES, COMMONLY CALLED "ICE MACHINES."

No. 336,235. Patented Feb. 16, 1886.

Fig. 1.



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By Wm. G. Bulton
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N. PETERS, Photo-Lithographer, Washington, D. C.

(No Model.) 4 Sheets—Sheet 2.

E. E. HENDRICK.

MACHINE FOR COOLING LIQUIDS AND OTHER ARTICLES, COMMONLY CALLED "ICE MACHINES."

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Fig. 2.

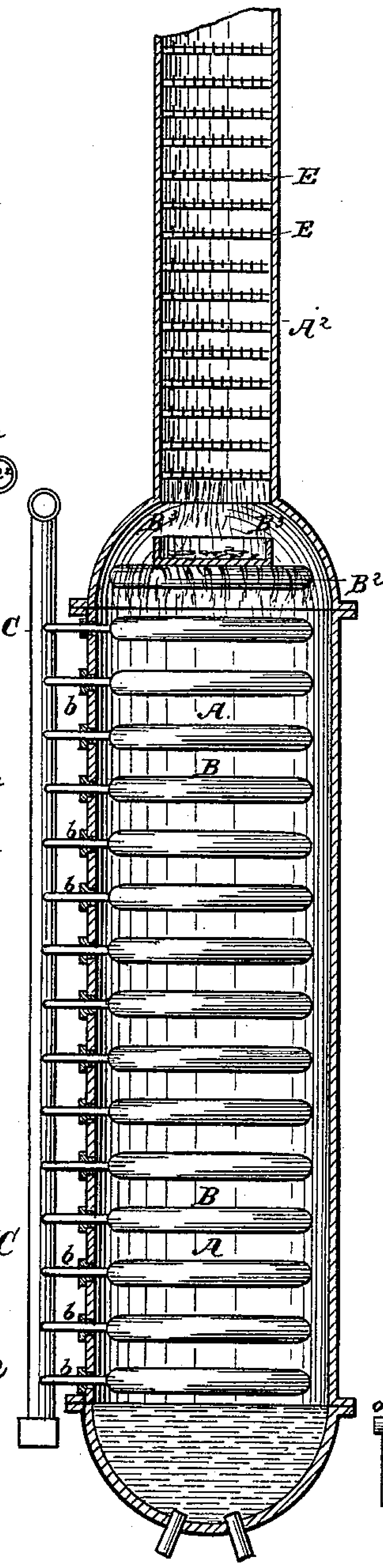


Fig. 4.

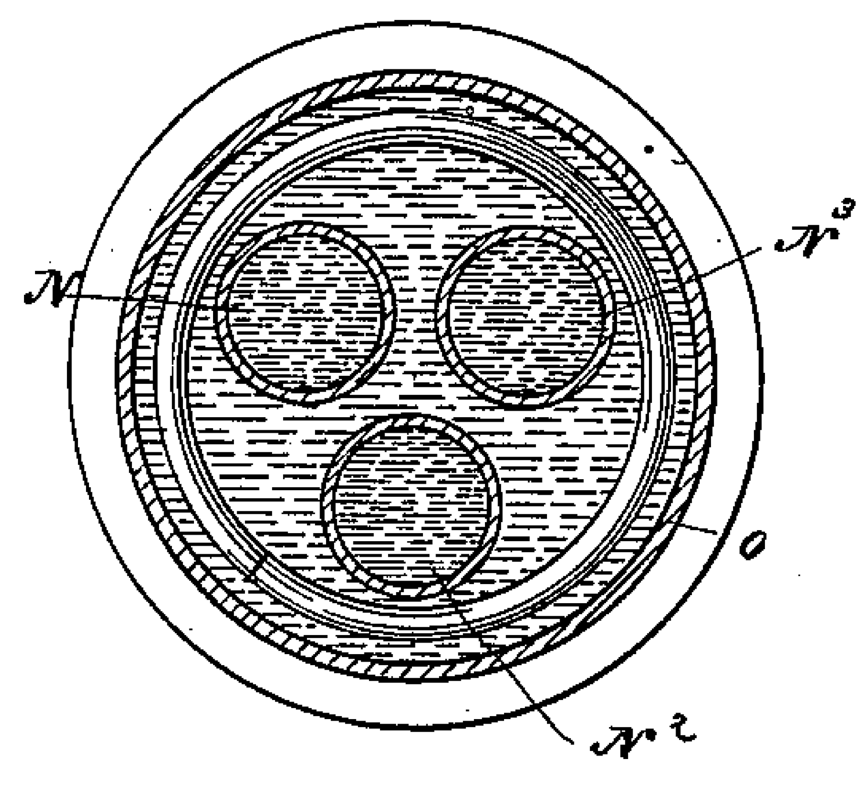


Fig. 6.

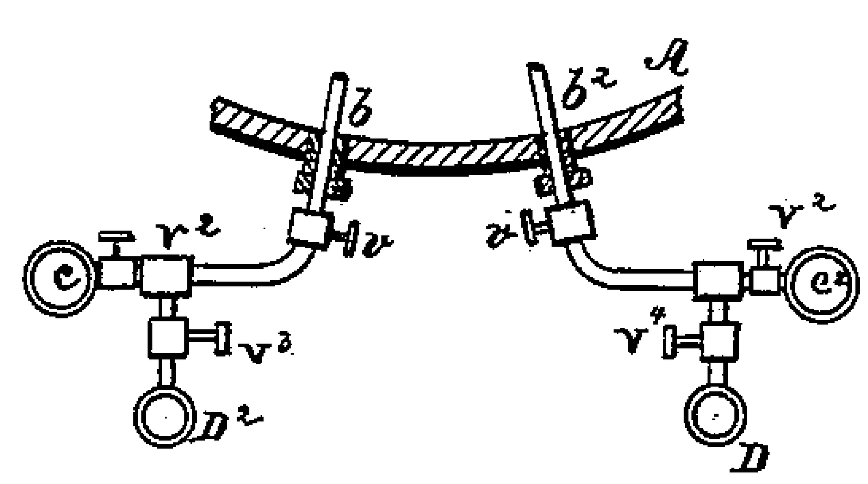


Fig. 3

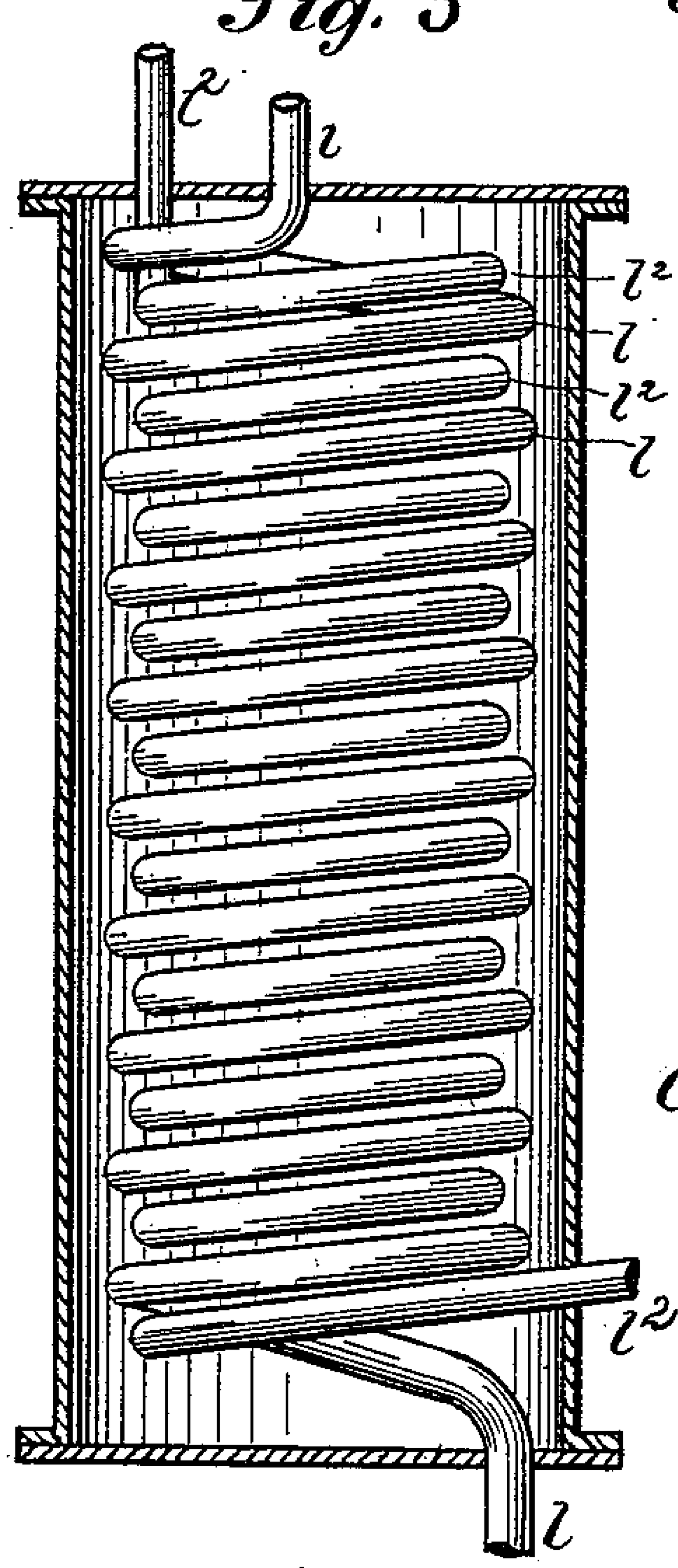
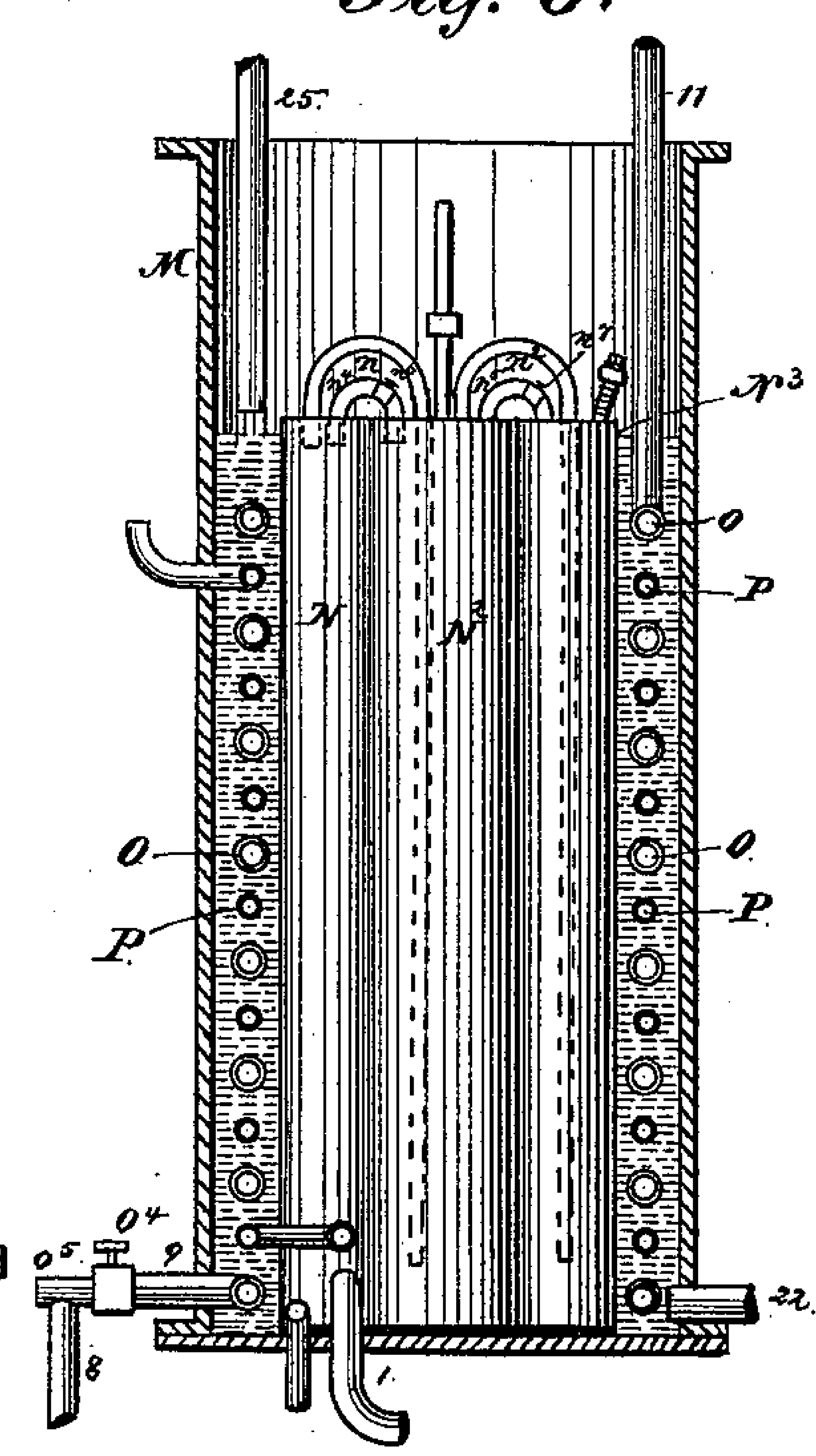


Fig. 5.



Witnesses:
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(No Model.) 4 Sheets—Sheet 3.

E. E. HENDRICK.

MACHINE FOR COOLING LIQUIDS AND OTHER ARTICLES, COMMONLY CALLED "ICE MACHINES."

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Fig. 7.

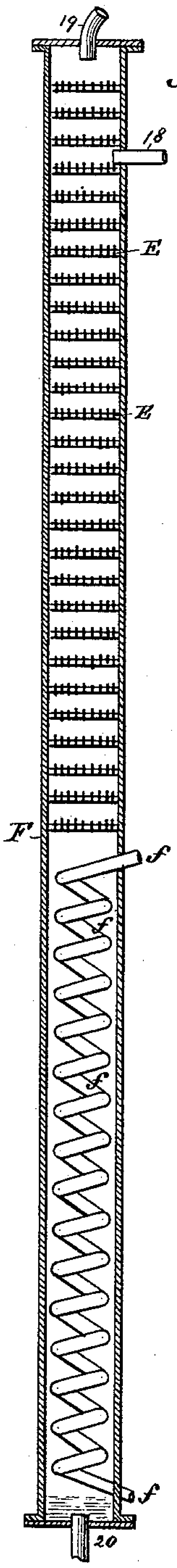


Fig. 9.

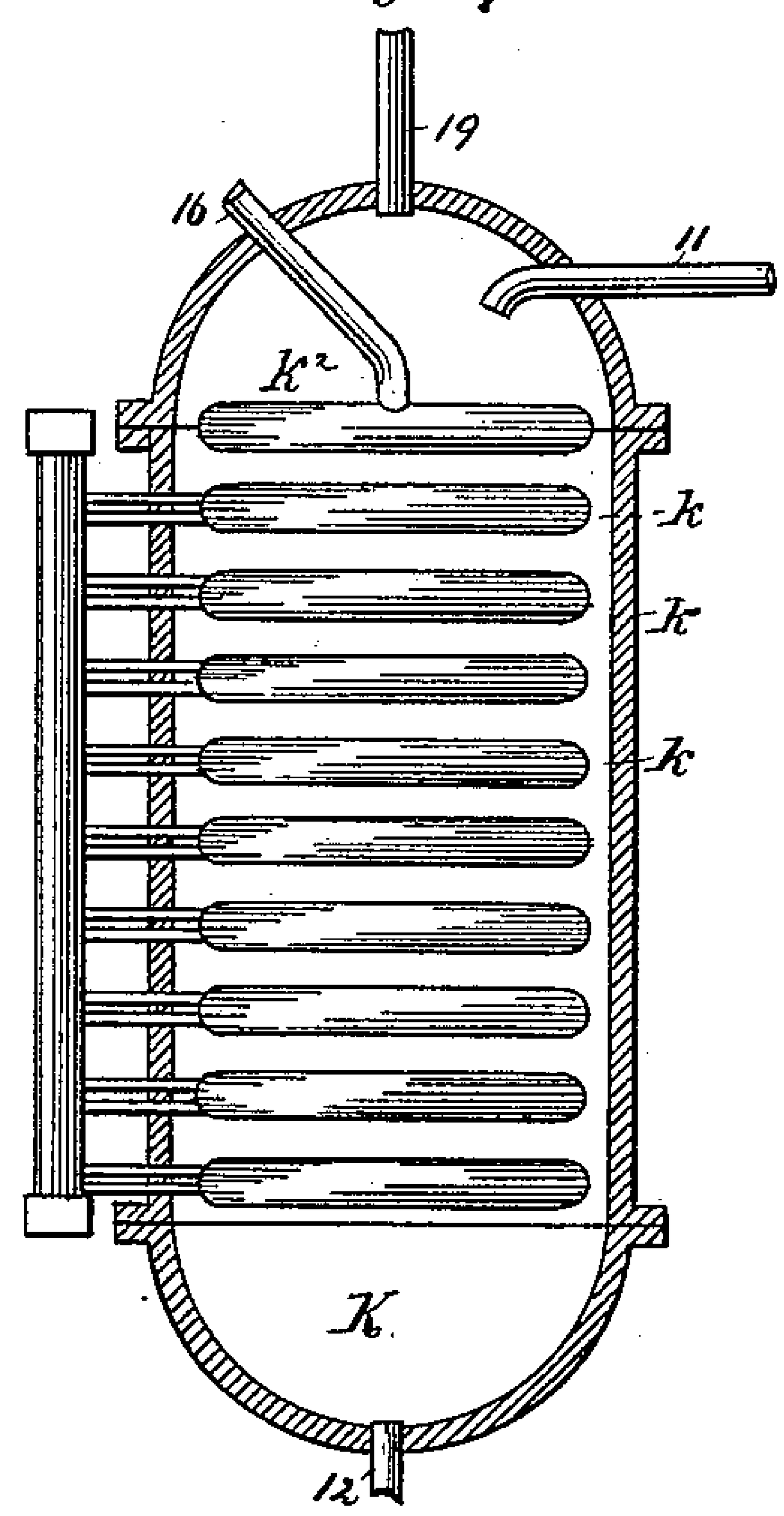


Fig. 10.

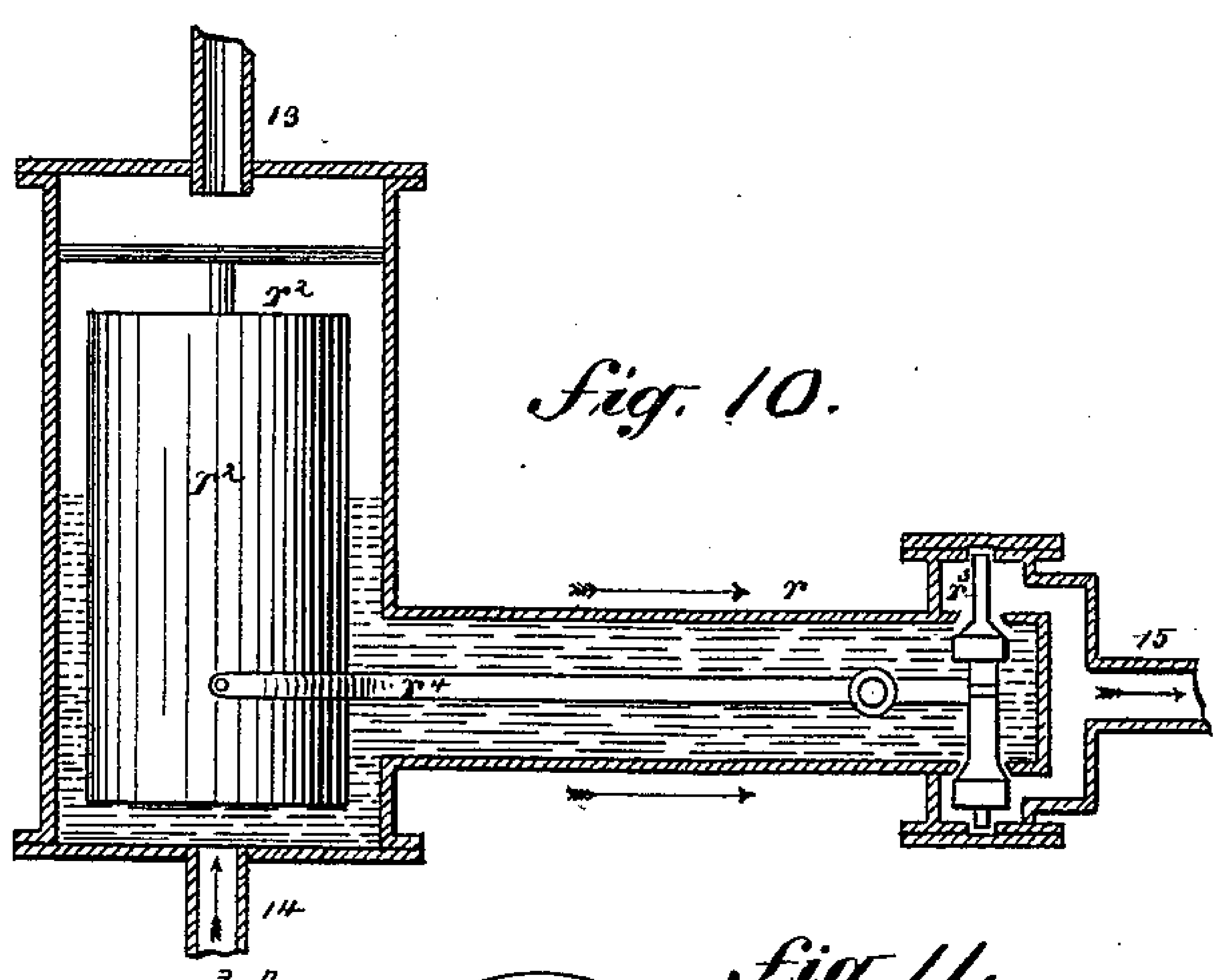


Fig. 11.

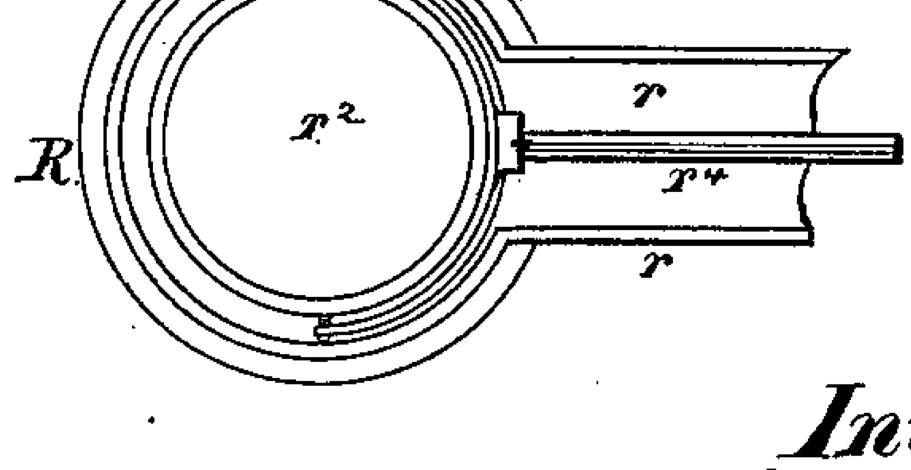
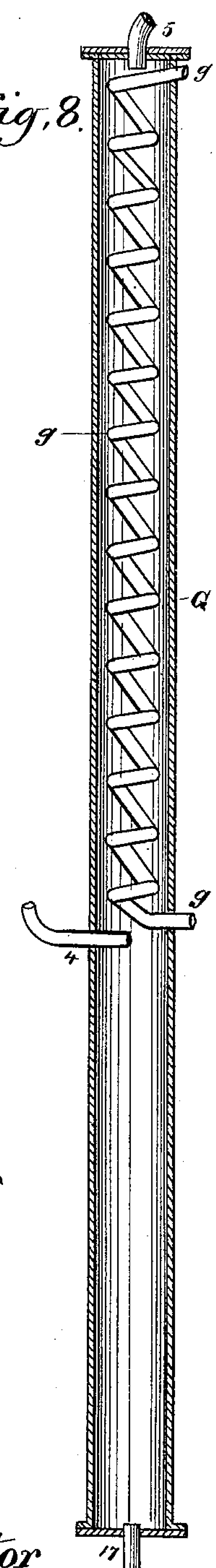


Fig. 8.



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MACHINE FOR COOLING LIQUIDS AND OTHER ARTICLES, COMMONLY CALLED "ICE MACHINES."

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Fig. 12

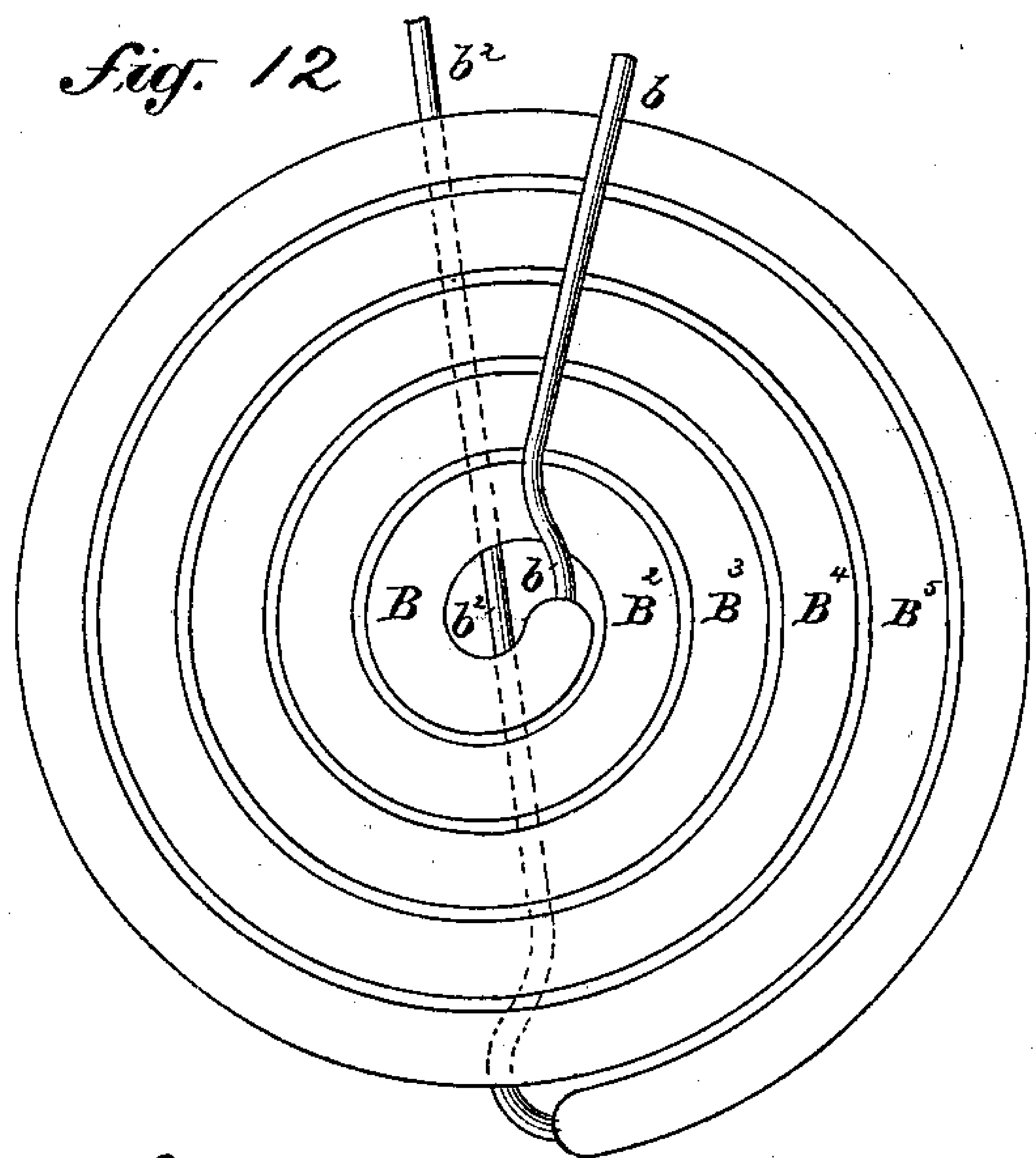


Fig. 13.

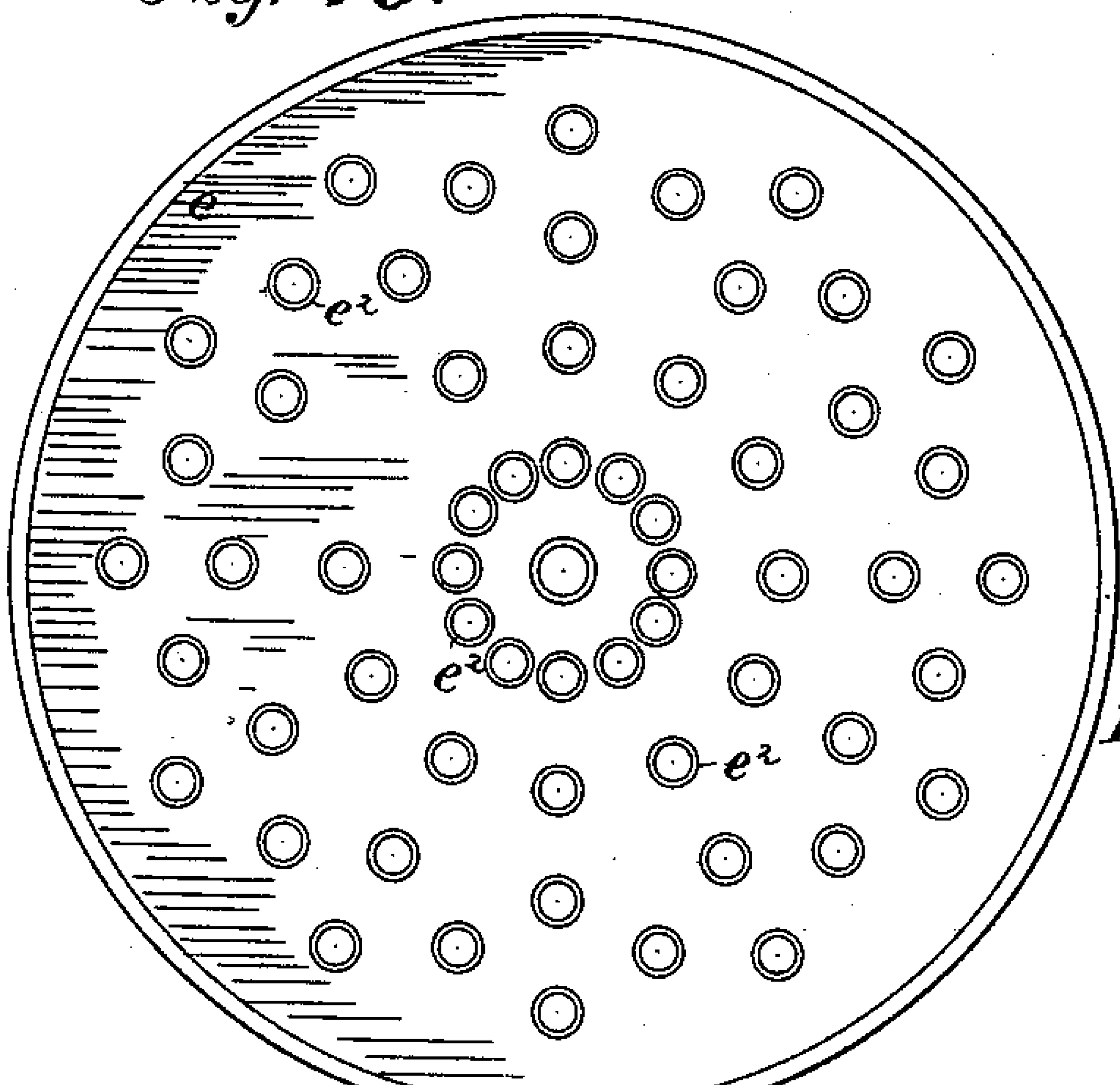
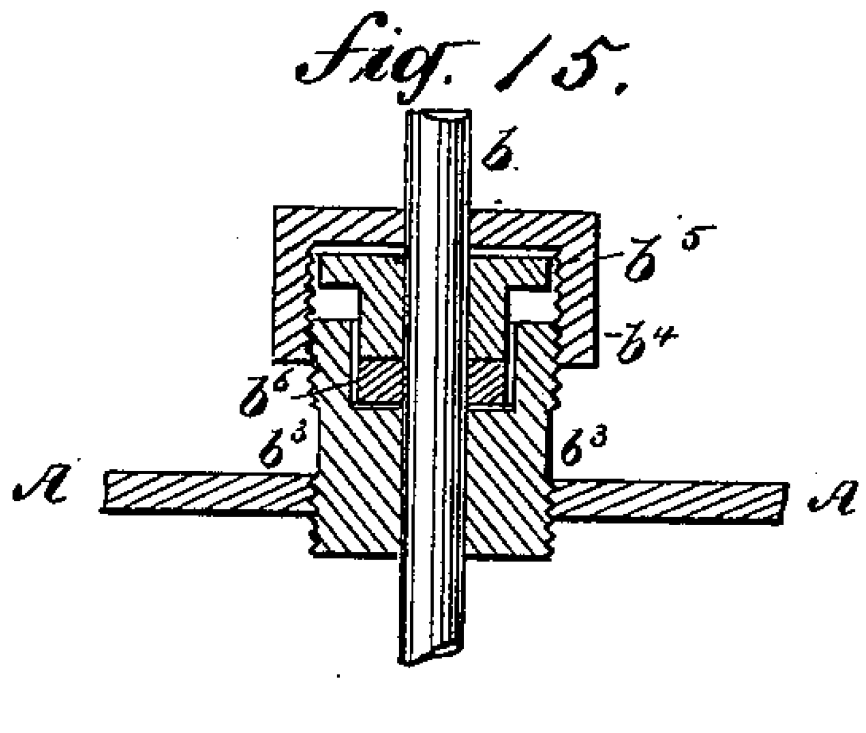


Fig. 14.

Fig. 15.



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UNITED STATES PATENT OFFICE.

ELI EMORY HENDRICK, OF CARBONDALE, PENNSYLVANIA.

MACHINE FOR COOLING LIQUIDS AND OTHER ARTICLES, COMMONLY CALLED "ICE-MACHINES."

SPECIFICATION forming part of Letters Patent No. 336,235, dated February 16, 1886.

Application filed January 11, 1886. Serial No. 188,202. (No model.)

To all whom it may concern:

Be it known that I, ELI EMORY HENDRICK, of Carbondale, in the county of Lackawanna and State of Pennsylvania, have made an invention of certain new and useful Improvements in Machinery for Cooling Liquids and other Articles, commonly called "Ice-Machines," and in the Art of Artificial Refrigeration; and I do hereby declare that the following, in connection with the accompanying drawings, is a full, clear, and exact description and specification of the same.

My improvements have reference to that class of machines for cooling liquids and other articles in which ammonia or other gas which can be separated by heat from a liquid and then condensed to the liquid condition by pressure may be employed to abstract heat from a body to be cooled by the evaporation of the liquefied gas; and the object of the improvement is to economize the fuel which is required to liberate the gas from the liquid which contains it and to condense the gas by mechanical pressure to the liquid condition.

The leading principles which are involved in the invention set forth in this patent are the utilization of the mechanical force of steam mainly to develop the power required to condense the liquefiable gas to the liquid condition and the subsequent utilization of the heat of the spent or exhaust steam to liberate the said gas from the liquid which contains it, and also the compression of the gas in part by the accumulated tension due to the heating of the gas-furnishing liquid and in part by mechanical force.

The invention consists of certain combinations of apparatuses or devices and of a certain process or method, which are set forth in detail in the claims at the close of this description. The principal members of the said combinations are the following, viz: A still or other evaporator fitted with steam-heating devices by means of which ammonia or other gas can be liberated by heat from a liquid which contains it; a cooler by means of which the liberated gas may have its temperature reduced; a steam-engine by means of which the power required to compress the liberated gas is developed; a compressing-pump by means of which the gas may be condensed; a condenser by means of which the heat evolved by the compression of the gas is removed, so that the gas is liquefied; a reservoir for the liquefied gas; a refrigerator in which the liquefied gas is evaporated in contact with pipes or vessels containing the material whose heat is to be extracted; an absorber in which the vaporized gas is absorbed in a weak solution of it, so as to obtain a strong liquid suitable for being introduced into the still; an interchanger by means of which the strong liquid on its way to the still is heated by the weak or spent liquid drawn from the still; a receiver or tank which receives the liquid produced by the absorption of the gas and from which this strong liquid is supplied to the still; one or more pumps by means of which the liquids may be circulated through the apparatus; various pipes or other connections and valves by means of which the above members are connected. My said combinations are not restricted to any particular construction of each of the above members, as the construction may be greatly varied according to circumstances or the views of different constructers or users.

In order that my invention may be fully understood, I have represented in the accompanying drawings, and will proceed to describe, the best form of apparatus which I have thus far devised to embody my invention for practical use.

Figure 1 of the said drawings represents a side view of the entire apparatus. Fig. 2 is a vertical central section of the still which I prefer to use. Fig. 3 is a vertical central section of the interchanger. Fig. 4 is a horizontal section of the secondary absorber. Fig. 5 is a vertical section of the secondary absorber, showing the reservoir of liquid within it. Fig. 6 is a transverse section of a part of the still, showing the connecting-pipes between the manifolds and the steam-coils within the still. Fig. 7 is a central vertical section of a secondary still which I prefer to use. Fig. 8 is a central vertical section of the steam-trap. Fig. 9 is a central vertical section of the primary absorber. Fig. 10 is a central vertical section of the regulator for regulating the height of liquid in the still. Fig. 11 is a transverse section of the same. Fig. 12 is a plan of one of the coils of pipe which I prefer to use for the interior of the still. Fig. 13 is a plan of one of the drip-pans which I prefer to use in the upper section of the still. Fig. 14 is a central vertical section of the said drip-pan. Fig. 15 is a horizontal section of one of the stuffing-boxes of the still through which the supply and drain pipes of each heating-coil are passed.

The parts of the said apparatus which are new are fully described by me in another patent of even date herewith, to which reference may be had, and therefore I do not deem it necessary to describe them in detail herein, while the construction of the parts of this apparatus, which are old, is well understood by constructers and users of machinery used in the art to which this invention appertains, and therefore I do not deem it necessary to describe them in detail.

As I prefer to use ammonia as the liquefiable gas, the said apparatus is adapted to the use of gaseous ammonia, which may be liberated from commercial aqua-ammonia by heat. The still in which this liberation is effected is constructed, preferably, with an upper section, A^2, and with a lower section or body, A. This lower section is fitted, preferably, with a series of coils of pipes, B, into which steam may be conducted by means of two manifolds or distributing-pipes, C D, whose branches are connected with the respective series of pipes within the said still-section. The said series of coils constitute the steam-heating devices of the still, and they are also connected with two other manifolds or branch pipes, C^2 D^2, through which the condensed water from the series of coils within the said still section or body is permitted to escape. The branch from each manifold to each coil within the still is fitted with a valve, by means of which the supply of steam to each coil may be controlled. The bottom of the still-body is fitted with a pipe, 14, and valve through which the weak or spent aqua-ammonia from which the gas has been liberated may when necessary be permitted to escape. The upper section, A^2, of the still is fitted internally by preference with a series of shallow perforated drip-pans, E, so that the aqua-ammonia which is admitted to the top of the still by a pipe, 3, may drip successively from one pan to the other, while gaseous ammonia liberated in the body of the still by the heat from steam in the coils passes upward and heats the descending liquid. The gaseous ammonia which is liberated in the still passes through the gas-escape pipe 4, and is conducted, preferably, into a trap, G, the upper portion of which is fitted internally with a worm-pipe, *g*, through which cold water is circulated, so that any aqueous vapor which is mixed with the gaseous ammonia on its exit from the still may be condensed, leaving the gaseous ammonia practically anhydrous. The gaseous ammonia escapes from the top of the trap G through the pipe 5, which is connected with a worm-pipe of the cooler N, in its passage through which the gaseous ammonia is cooled by means of a current of water in the tank of the cooler in which the worm of the cooler is immersed, the cooling-water being introduced by the pipe 29 and permitted to escape by the pipe 28. The cool gaseous ammonia from the cooler is conducted by the pipe 5 to the compressing-pump U, by means of which the gaseous ammonia is sufficiently compressed to condense into a liquid form when cooled to the temperature which is attainable by the use of the liquid which is used to cool it. This compressing-pump is driven by the steam-engine Q in the usual manner, the construction of the steam-engine and compressing pump which I prefer to use being that which is commonly known as "Guild & Garrison's Improved Ammonia Compressor," (crank and fly wheel pattern.) The compressed gaseous ammonia is conducted directly from the gas compressing pump or compressor U through the pipes 5 to the condenser H, the said pipe being connected with the coil or worm contained in the tank of the condenser, and the compressed ammonia is cooled by the action of a current of water in the tank of the condenser in which the worm or coil is immersed, the cooling-water being introduced in the said tank by the pipe 27 and permitted to escape by the pipe 26. The lower end of the worm or coil of the condenser is connected with the reservoir I for the liquefied anhydrous ammonia which flows from the worm of the condenser, and this reservoir is preferably fitted with a glass-gage, *w*, and with an escape-pipe, 21, controlled by a valve, so that the user may take notice of any strong aqua-ammonia which may flow into the receiver from the condenser, and may at intervals permit it to escape through the escape-pipe 21. The liquefied anhydrous ammonia is conducted from the reservoir I by the pipe 7 to the refrigerator J.

As the apparatus represented in the drawings is designed to reduce the temperature of a practically uncongealable liquid, which is used as a medium to receive heat from rooms or from articles to be cooled, and to transfer that heat to the ammonia, the refrigerator J consists of a tank for the uncongealable liquid and of a coil of pipe which is immersed in the same. The anhydrous ammonia is conducted by the pipe 7 to the upper end of the said refrigerator-coil, and is vaporized by the heat of the uncongealable liquid from which the heat is abstracted. The vaporized ammonia is conducted by the pipe 10 to the absorber K, in which it is brought in contact with the spent ammonia from the bottom of the still A and is re absorbed, the re-absorption being facilitated by the cooling action of a current of water which is circulated through coils or pipe contained within the absorber.

In order to insure the absorption of the whole of the vapor, a secondary absorber, M, is provided, and is connected with the bottom of the primary absorber K by a pipe, 12, down which the aqua-ammonia and such gaseous ammonia as escapes absorption in the primary absorber pass to a coil of pipe, P, contained in the tank of the secondary absorber. This absorbing-coil of pipe is kept cool by being immersed in a bath of non-congealable liquid, and the aqua-ammonia from the absorbing-coil is conducted into the strong aqua-ammonia receiver N, from which the still is supplied by means of the steam-pump S. Additional aqua-ammonia receivers, N^2 N^3, are fitted into the tank M of the secondary absorber, and the additional receivers are connected in series with the first receiver, N, by means of pipes n, so that any vapor of ammonia which escapes unabsorbed from the first receiver is condensed in the water or weak ammonia with which the additional receivers are fitted at the commencement of the working apparatus. In case the first receiver does not afford a supply for the still as it is required, either fresh ammonia is introduced into the receiver, or, if the ammonia in the second receiver has become strong enough, a supply from it is transferred to the first receiver, and the ammonia from the second additional receiver is transferred to the one next the first receiver.

In order that the secondary absorber may be kept as cool as possible, it is fitted with a second coil, O, whose members alternate with those of the absorption-coil P, and this second coil is connected at each end with the pipes 10 11, which conduct the vapor of ammonia from the refrigerator J, so that by setting the valves in the pipes properly the current of cool ammonia vapor from the refrigerator may be caused to pass through the said second coil, O, in the secondary absorber on its way to the primary absorber, instead of being permitted to pass directly through the pipes 10 11 to the primary absorber, and that the cool ammonia vapor may thus abstract heat from the bath of liquid in the secondary absorber and thereby cool the absorbing-coil P. The said cooling-coil O of the secondary absorber is also connected by a pipe, 8, and valves with the receiver I of the anhydrous ammonia, so that when a greater cooling action in the secondary absorber is desirable anhydrous ammonia may be admitted to the cooling-coil O and vaporized therein, the vapor then passing upward through the pipe 11 to the primary absorber K. The water which is generally used to keep the primary absorber cool is conveyed by the pipe 24 to the manifold, which is connected with the coils in the primary absorber, and is discharged through the manifold connecting with the other ends of the coils and permitted to escape. When, however, the temperature of the water which is available for cooling is not low enough, the cool uncongealable liquid in the tank of the secondary absorber may be circulated through the coils of the primary absorber K and may be returned to the tank of the secondary absorber. In this case the supply of cooling-water is shut off and the circulating-pump T is put in operation. This pump takes the uncongealable liquid from the secondary absorber through the pipe 22 and forces it through the pipe 23 into the coil of the primary absorber, whence it is returned through the pipe 25 to the tank of the secondary absorber M.

In the use of the said apparatus I prefer to maintain the level of the aqua-ammonia in the still A below the level of the lowest coil of heating-pipes, and for this purpose I employ the regulator R, which contains a float operating a valve, as represented fully in Fig. 10, whereby the spent aqua-ammonia is permitted to escape from the still whenever it exceeds the level determined by the regulator. This spent ammonia, as before described, is conveyed to the absorber to re-absorb the anhydrous vapor of ammonia. In order that the heat of this spent ammonia may be eliminated to a greater or less extent, and may be utilized to warm the strong aqua-ammonia which is supplied from the receiver N to the still, the discharge-pipe 15 from the regulator is not connected directly with the primary absorber K, but is connected with it through the intervention of the interchanger L, while the pipe 2, through which strong aqua-ammonia is supplied to the top of the still, is not connected directly with the top of the still, but is connected with it through the intervention of the same interchanger L. The interchanger L is constructed, by preference, of a tank containing two independent coils of pipe whose members alternate. One of these coils of pipe, 1, is connected at its upper end with the pipe 15, proceeding from the regulator, and is connected at its lower end with the pipe 16, proceeding to the absorber. The other coil of pipe 1^2 is connected at its lower end with the pipe 2, proceeding from the aqua-ammonia supply-pump, and is connected at its upper end with the pipe 3, proceeding to the top of the still; hence the current of warm spent aqua ammonia escaping from the bottom of the still passes in a downward direction through one of the coils of the interchanger to the absorber, while the supply of strong aqua-ammonia taken from the ammonia-receiver by the pump S passes in an upward direction through the second coil of the interchanger to the top of the still. The tank of the interchanger is filled with any suitable liquid—such as water—which surrounds the two coils of pipe, receives heat from the spent aqua-ammonia in one coil and transfers it to the strong aqua-ammonia in the other coil, so that the temperature of the spent ammonia is reduced before it enters the absorber and the temperature of the strong aqua-ammonia is raised before it enters the top of the still. The trap G is connected at its bottom with the bottom of the still A, and with the regulator R, by means of the pipes 17 14, so that any aqua-ammonia which condenses in the trap may be permitted to escape. A secondary still, F, is provided to operate upon either weak ammonia taken from the bottom of the still by the pipe 18 or upon a fresh supply of ammonia that may be introduced into it. The aqua-ammonia in this secondary still is heated by a coil of pipe into which steam is admitted through the pipe *f*, while the condensed water is permitted to escape through the pipe f^2. The liberated gaseous ammonia from this secondary still is conducted by the pipe 19 to the primary absorber K, and the spent aqua-ammonia is permitted to escape at intervals from the bottom of the secondary still through the pipe 20.

The various pipes in the apparatus are fitted with valves, (all of which are designated *v*,) so that the flow of fluid through each pipe may be controlled as may be necessary.

In order that the first leading feature of my present invention may be embodied in the said apparatus the valve-chest of the steam-engine Q is connected with the steam-boiler by means of a steam-pipe in the usual manner, and the exhaust-pipe of the steam-engine is connected by means of the pipe 30 with the upper end of the manifold C, which supplies steam to the series of coils within the still-body, so that the steam may first have its mechanical force utilized in the compression of the gaseous ammonia, and that then the available heat of the spent or exhaust steam may be utilized to liberate the gaseous ammonia from the aqua-ammonia in the still. By thus using the exhaust-steam from the compressing-engine to liberate the gas in the still the use of steam taken directly from the boiler for that purpose is saved, with considerable economy of fuel. The exhaust-pipes from the circulating-pumps S T may also be connected with the same manifold C, so as to utilize the heat of the exhaust-steam from these pumps. The condensed water from the series of coils in the still-body supplied with exhaust-steam is permitted to escape through the manifold D.

In order that an additional supply of heat may when necessary be furnished for the liberation of the gaseous ammonia in the still, a second manifold, D, is provided to supply a portion of the coils in the still with steam taken directly from the steam-boiler, and the condensed water is permitted to escape from the coils so supplied through the manifold D^2.

In order that the exhaust of steam from the steam-engine may not be materially choked in case there is more exhaust-steam than is necessary to heat the aqua-ammonia in the still, a relief-valve, X, is placed in the exhaust-pipe, so that whenever the pressure of the exhaust-steam exceeds the desired limit the surplus escapes through the relief-valve.

In the operation of the before-described apparatus the gaseous ammonia is liberated from the aqua ammonia under confinement in the still by the heat of the steam in the steam-coils, and by reason of the confinement and heat the tension of the liberated gas is progressively increased, so that the gas upon which the compressing-pump and steam-engine act is already materially compressed by the accumulated tension. Consequently, the capacity of the compressing-pump may be reduced as compared with one operating upon gas liberated from cool anhydrous ammonia, and the power required in the steam-engine to carry on the compression to the degree required to cause the liquefaction of the gas when cooled is materially reduced.

My present invention is not restricted to the precise form of apparatus represented in the drawings, as the construction of the members of this apparatus may be greatly varied without ceasing to embody the invention. Moreover, some of the members hereinbefore described may be omitted. Thus in the apparatus represented in the drawings the pipes 4 5 5, the trap G, and cooler W connect the still with the compressor U and form the connection between the two; but if the liberated gaseous ammonia leaving the still is not to have the aqueous vapor separated from it, or if this operation is performed sufficiently in the still, the trap may be omitted and the escape-pipe 4 from the still may be conducted directly to the cooler W. On the other hand, if the cooling of the gaseous ammonia is to be omitted, the cooler W may be dispensed with and the connection from the still to the compressor may be made directly or through the intervention of the trap G or its substitute. I do not, however, recommend this modification. If deemed best, the interchanger L may be omitted and the warm spent ammonia may be cooled by other means, while the strong ammonia may be supplied to the still either directly or through the cooling-coil *g* in the trap G. A single absorber may be used, if deemed best, and the condenser may have the lower end of its coil enlarged, so as to form the reservoir for the liquefied gas, thus dispensing with a sepaıate reservoir.

The object of maintaining the level of the aqua-ammonia in the still-body below the level of some of the coils in the still body is to permit the larger part of the gas in the liquid to be liberated quietly from the thin film of liquid dripping or flowing over the coils of pipes, and thus avoid the violent ebullition that would occur if the liquid covered the heating-pipes before a portion of the gas was liberated from it. The regulator is not essential to this method of working, as the same result may be attained by regulating the escape under pressure of the spent aqua-ammonia from the bottom of the still by means of a cock or a screw-valve in the escape-pipe, which cock or valve may be occasionally regulated by the attendant; and there is always sufficient pressure of gas in the still-body to force out the spent aqua-ammonia and drive it to the absorber.

I do not claim in this patent the improvements which are claimed in my other patents of even date herewith.

I claim in this patent as my invention—

1. The combination, substantially as before set forth, of the still fitted with steam-heating

devices, the compressing-pump, and the steam-engine that drives it, by connections whereby the exhaust-steam from the steam-engine that drives the compressing-pump is supplied to the steam-heating devices of the still and the gas liberated in the still is conducted to and compressed by the compressing-pump.

2. The combination, substantially as before set forth, of the still fitted with steam-heating devices, the compressing-pump, the steam-engine, the condenser, and the reservoir of liquefied gas, by means of connections, whereby the exhaust-steam from the steam-engine that drives the compressing-pump is supplied to the steam-heating devices of the still, the gas liberated in the still is conducted to the compressing-pump, the compressed gas is conducted to the condenser, and the liquefied gas is conducted to the said reservoir.

3. The combination, substantially as before set forth, of the still fitted with steam-heating devices, the compressing-pump, the steam-engine that drives it, the condenser, the reservoir of liquefied gas, the refrigerator, and the absorber, by means of connections, whereby the exhaust-steam from the said steam-engine is supplied to the steam-heating devices of the said still, the gas liberated from the said still is compressed by the compressing-pump driven by the said engine, the compressed gas is condensed into the said reservoir, the liquefied gas from said reservoir is conducted to the refrigerator, the gas from the refrigerator is conducted to the absorber, and is therein absorbed by the spent liquid from the still.

4. The process of refrigerating an article substantially as before set forth, consisting of the following operations, viz.: the liberation by heat of gas from a solution of gas in a liquid under confinement, so that the gas is partially compressed to the required degree by its accumulated tension, the reduction of the partially-compressed gas to the liquefied condition by mechanical force and by cooling it, the cooling of the article by the evaporation of the liquefied gas, and the absorption by a liquid of the gas resulting from the evaporation.

5. The method, substantially as before set forth, of preventing the violent ebullition of liquid in the still by causing the liquid to flow over the heating-pipes of the still, and by maintaining the level of liquid below some of said heating-pipes.

In witness whereof I have hereunto set my hand.

ELI EMORY HENDRICK.

Witnesses:

WILLIAM G. BUTTON,
GEORGE H. SONNEBORN.